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Advances in Climate Change Research 7 (2016) 204–212

www.keaipublishing.com/en/journals/accr/

Global low-carbon transition and China's response strategies

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Received 7 April 2016; accepted 28 June 2016
Available online 22 July 2016

Abstract

The Paris Agreement establishes a new mechanism for post-2020 global climate governance, and sets long-term goals for global response to climate change, which will accelerate worldwide low-carbon transformation of economic development pattern, promote the revolutionary reform of energy system, boost a fundamental change in the mode of social production and consumption, and further the civilization of human society from industrial civilization to eco-civilization. The urgency of global low-carbon transition will reshape the competition situation of world's economy, trade and technology. Taking the construction of eco-civilization as a guide, China explores green and low-carbon development paths, establishes ambitious intended nationally determined contribution (INDC) targets and action plans, advances energy production and consumption revolution, and speeds up the transformation of economic development pattern. These strategies and actions not only confirm to the trend of the world low-carbon transition, but also meet the intrinsic requirements for easing the domestic resources and environment constraints and realizing sustainable development. They are multi-win-win strategies for promotion of economic development and environmental protection and mitigation of carbon emissions. China should take the global long-term emission reduction targets as a guide, and formulate medium and long-term low-carbon development strategy, build the core competitiveness of low-carbon advanced technology and development pattern, and take an in-depth part in global governance so as to reflect the responsibility of China as a great power in constructing a community of common destiny for all mankind and addressing global ecological crisis.

Keywords: Climate change; Low-carbon transformation; Energy revolution; CO_2 emission reduction

1. Introduction

Global climate change threatens the earth's ecological safety as well as human survival and development. It is one of the biggest threats facing humanity. Since the United Nations Framework Convention on Climate Change (hereinafter referred to as the Convention) was adopted in 1992, the world has cooperated in global response to climate change. Paris climate conference in December 2015 successfully reached an Agreement, establishing the long-term goals and a new mechanism for post-2020 global response to climate change, which promotes the process of global cooperation. Low-carbon transition against the background of global response to climate change will surely have a significant impact on the pattern and pathway of China's future economic and social development.

2. New global governance model of Paris Agreement accelerates the global low-carbon transition

The Paris Agreement makes an arrangement for the system of post-2020 global response to climate change action. It is an Agreement that is of legal force and applies to all countries (UNFCCC, 2015). Following the Kyoto Protocol, it becomes a new start and a milestone for global response to climate change under the guidance of the Convention. The new

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Peer review under responsibility of National Climate Center (China Meteorological Administration).

Production and Hosting by Elsevier on behalf of KeAi

http://dx.doi.org/10.1016/j.accre.2016.06.007

mechanism of global climate governance adopted by the Paris Agreement reflects a new concept of global governance that all parties cooperate voluntarily in the common interest of the globe and all humans.

The Agreement establishes the long-term goals for the global response to climate change, that is, to hold the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. The global cooperative action to reduce carbon emissions will be guided by the above goals and be based on the parties' bottom-up INDCs. Information is provided for the parties to help them continue to update and strengthen their INDC objectives and efforts by enhancing transparency of mitigation and support and global regular collective summary or inventory. Under the principle of common but differentiated responsibilities, the global long-term goals are to be achieved through all parties' voluntary cooperation, and continuous and conscious efforts to strengthen the mitigation and support actions. This new global governance mechanism aims to create a community of common destiny for all mankind, and work together to tackle the common crisis of the earth and human beings. Under the new regime, parties need to abandon the narrow thinking of traditional "zero-sum game", and shift to a win–win cooperation of total-sum game. The new mechanism is no longer a top-down allocation and sharing of responsibilities and obligations, but becomes the parties' voluntary acts after coordinating and balancing the common interests of the globe and all mankind, their own interests and sustainable development under the long-term global goals. This mechanism based on voluntary action also reflects all parties' consciousness of responsibility and political mutual trust in tackling the global ecological crisis. The Paris Agreement emphasizes on climate justice, and abides by common but differentiated responsibilities, fairness and respective capacity of the Convention. The key lies in that all countries can achieve sustainable development fairly in the cooperative action to deal with climate change. It urges all countries, especially developing countries to combine addressing climate change, eliminating poverty and their own sustainable development, taking a climate-friendly low-carbon development path, and achieving a win–win development and carbon reduction. The global governance which manages ecological crisis represented by climate change reflects the common interests of all mankind. The new pattern of the governance promotes the construction of a community of common destiny for all mankind—all countries cooperate voluntarily and work together to build a win–win, fair and reasonable mechanism. International cooperation on climate change will surely further the common development of all countries to realize mutual benefit and win–win situations.

The Agreement creates a new model of global governance to deal with environmental crisis, but its implementation is still facing many challenges and arduous tasks. The Agreement makes it clear that to control the global temperature rise no more than 2 °C, a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHGs)—net zero emissions of GHGs—should be achieved in the second half of the 21st century, which means the end of the era of fossil fuels by that time. That helps to accelerate the pace of economic and energy low-carbon transformation, and will lead to revolutionary changes in economic development pattern, social governance model and the energy system, thereby reshaping the competition pattern of international economy and technology. All countries will face severe challenges and arduous tasks.

China has played a prominent role in reaching the Paris Agreement and advancing the construction of a new global governance mechanism. Sino-U.S. and Sino-French joint statements on climate change published before the Paris conference built consensus on the core and focus for the Agreement, acting as a base. In particular, General Secretary Xi Jin-Ping, in his opening speech, put forward a new global governance idea—to promote the construction of a community of common destiny for all mankind, by which he means to create a future of win–win cooperation, with each country making contribution to the best of its ability, of the rule of law, fairness and justice, and of inclusiveness, mutual learning and common development. China has actively promoted the success of the Paris climate conference, serving as a good example of the practice of General Secretary Xi's new concept and China's in-depth participation in global governance.

China actively promotes the construction of a new global governance mechanism of win–win cooperation, fairness and justice, and common development in the international community, which provides positive energy for and plays a constructive and leading role in dealing with global environmental change and human sustainable development. This reflects China's consciousness of responsibility, as a big country, for the common interests of mankind and common development of all countries. Besides, with the global trend of low-carbon transition, China will actively promote the transformation of economic development pattern, and energy production and consumption revolution domestically, so as to achieve green, recycling and low-carbon development, conform to the changes of economic and technological competition pattern in global low-carbon transformation, and build core competitiveness for its own low-carbon development. China will also make its contribution to addressing ecological crisis and achieving sustainable development globally.

3. Global low-carbon transformation will promote fundamental changes in economic and social development pattern

Low-carbon development in response to global climate change is the only way to protect the earth's ecology and human survival and development, and the voluntary cooperative acts of all parties to protect the common interests of all mankind. The situation is urgent, and the task is arduous, therefore all countries should establish ambitious goals and constantly increase the ambition in their actions. Besides, low-carbon transformation involves all economic fields and all aspects of society, thus governments, businesses, and people of all countries should act together. The transformation will lead to fundamental changes in the pattern of economic development, the concepts

of social values and the mode of public consumption and so on, affecting the evolution of human civilization.

3.1. To bring revolutionary reform of energy system

To achieve the goal of controlling the global temperature rise below 2 °C (or even 1.5 °C), the core is to curb and reduce the anthropogenic GHG emissions. Since CO_2 emissions from fossil energy consumption account for 2/3 of global anthropogenic GHG emissions, and is usually shown as large-scale and concentrated emission sources, it becomes the most important area of emission reduction. Urgency of the global response to climate change will accelerate the revolutionary reform of energy system. On one hand, it will promote energy conservation and efficiency, reducing the consumption of fossil energy; on the other hand, it will accelerate development of new and renewable energy, including wind power, hydropower, solar power, biomass and nuclear power etc., and will decrease the proportion of fossil energy in total primary energy consumption, boosting decarbonization of energy system and cutting CO_2 emissions from energy consumption.

The Paris Agreement proposes to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHGs—net zero emissions of GHGs—in the second half of the 21st century, which means replacing gradually the high-carbon traditional energy system dominated by fossil fuels with a low- or zero-carbon system dominated by new and renewable energy, ending the era of fossil fuels by second half of the 21st century. Formulating ambitious goals and countermeasures of energy decarbonization reform has become the strategic choice of major countries. Germany, for example, proposed to reduce the total primary energy consumption by 50% in 2050, and improve the proportion of renewable energy in primary energy consumption to 60%, so that the CO_2 emission reduction would reach 80%. Global trend of change in energy promotes new energy technological innovation and industrialization. The technology of power generation using wind power, solar power etc. is maturing fast; moreover, with high speeds, the cost is declining and the economy is increasing, and in some cases new energy can even compete with conventional energy. Because of the urgent situation of global carbon emissions mitigation, new energy industry will attract thousands of billions of dollars of investment. It will become new sources of economic growth and a strategic emerging industry, as well as the strategic high-tech industry of big countries and the front edge and hotspot of global economic and technological competition. Walking in the front of the march of new energy reform and seizing the initiative will reflect a nation's core competitiveness and help it play a leading role in global reform (He, 2015a).

3.2. To introduce reforms in economic development concepts and production modes

According to the concept of traditional economics, development takes promoting economic growth as the core, and means to increase the output rate of factors of production by optimizing the allocation of resources, and to maximize consumption utility of the public and the society, which supported and guided the development of world industrialization. However, since the industrial revolution, while sustaining the economic and social development, anthropogenic activities have excessively consumed the limited resources on the earth, and discharged too much waste, which are far beyond the earth's environmental carrying capacity, causing the global ecological crisis with the current climate change as a representative. When the 1992 United Nations Conference on Environment and Development adopted the Convention, it actively promoted the idea and mode of sustainable development, which coordinates the relationship between the three pillars—economic development, social progress and environmental protection. With a theme of developing green economy to promote poverty reduction and sustainable development, the 2012 Rio + 20 Conference on Sustainable Development paid much attention to the fairness of development and the coordination and sustainability of economy, resources and the environment (UN, 2012). To deal with the global ecological crisis, the traditional concept and mode of development should be changed, and a sustainable development path of coordinated economic society and resources and the environment as well as harmonious development of man and nature should be sought for, which will also boost a fundamental reform in the concept and mode of development.

Due to the 2 °C global temperature controlling target, the future urgent emission reduction process will have all countries face severe challenges of limited carbon space, and carbon emission space will become increasingly scarce resources. The carbon price mechanism, including carbon tax, carbon markets etc., gradually adopted by countries worldwide reflects the value of the space as scarce resources, and the properties as factors of production. Development of the centralized factory production since the industrial revolution needs the aggregation of labor, thereby producing the labor market and the working class living by selling labor, and the core of the mode of production is to improve the labor productivity. With the development of industrialization and urbanization, large-scale industrial, commercial, transportation and urban infrastructure construction needs a lot of money, and capital and financial markets came into being, which helped to make improving capital output rate more important business philosophy. In the future, capacity of the environment in terms of the carbon emission space will become the most scarce natural resources and factors of production, and the development of worldwide carbon price mechanism and carbon markets will make people pay more attention to the improvement of carbon productivity, that is, the rise of the economic output benefit of per unit carbon emissions. That indicates the decarbonization of economic development, which means more attention will be attached to resources and energy conservation, resources recycling, and clean, efficient use of energy. Green, recycling and low-carbon will become the core of the concept of new production patterns.

Under the new concept of development and mode of production, resources saving, environment protection and low-

carbon production will become the core values of enterprises and the core content of corporate social responsibility. Besides, with the advance in low-carbon transition, new economic and trading rules will develop, including increasingly strict low-carbon standards for products, carbon price mechanism like carbon tax and carbon markets, and carbon footprint label. That will reshape the international competition pattern of business, and low-carbon will become an important manifestation of the core competitiveness of enterprises.

3.3. To bring changes in values and consumption pattern

With the economic and social development and the rise of environmental awareness, social values will change tremendously, so do people's concepts of wealth, welfare, consumption and way of life. The traditional values emphasizing the acquisition and accumulation of material wealth and the pursuit of material enjoyment is challenged. The response to global ecological crisis draws more and more attention to ecology protection and environment quality improvement, and to the value of natural resources and the environment as assets and services. Good ecological environment is the most inclusive public property and fairest social welfare, and is the benefits and wealth shared by all people. Global climate change causes the earth's ecological destruction and extreme disaster events, whose negative effects affect every country and each individual. Everyone's consumption patterns also directly affect the well-being of the society and others. CO_2 emissions from private cars will accumulate in the atmosphere and produce a greenhouse effect, and the PM2.5 from exhaust emissions constitutes a source of urban haze. Under the premise that the basic material demand is met, clean air and water, good climate and ecological environment have become more important than physical enjoyment. High-quality life needs everyone's efforts to create, and will be shared by everyone, and cannot be separately obtained and enjoyed. The change in values will help to alter the public concept of consumption and lifestyle, making frugal low-carbon consumption a social morality and guiding and regulating the public consumption behavior. Green building, low-carbon travel, energy saving and carbon reduction will become the public's conscious choice of behavior and universal values under the idea of eco-civilization, thereby promoting the construction of low-carbon society (He, 2014; He et al., 2014; Jeremy, 2009).

3.4. To lead the civilization of human society to eco-civilization

Since the industrial revolution, with the progress of science and technology, developed countries have consumed a lot of the earth's limited fossil energy and other resources and excessively occupied the earth's environmental capacity. Although they created a highly developed industrial civilization, the world paid heavy resources and environment costs, which led to the global ecological crisis represented by climate change. Therefore, industrialization created by developed countries cannot sustain, and industrial civilization is an unsustainable form of social civilization. The population in developed countries only accounts for 20% of the globe. There are no resources and environmental conditions for developing countries, which have the majority of the world population, to follow developed countries in their industrialization and modernization process. As for developing countries, it is not possible to copy the industrial civilization development model, and a new path of coordinated development between economy, society and resources environment should be explored. Following the industrial civilization, eco-civilization will be a new form of civilization of human society. The current worldwide low-carbon transition will promote human civilization from industrial civilization to eco-civilization, so that human development will obey the rule of the earth's biosphere. Then, limited resources of the earth are no longer blindly taken in the process of economic and social development, wastes are no longer discharged to the earth's environment, and man and nature's harmonious and sustainable development is achieved. Human society will also shift to the zero-carbon times of eco-civilization supported by renewable energy from the high-carbon era of industrial civilization with fossil energy as a pillar (He, 2014).

4. Strategic thoughts for China's response to global low-carbon transition

China initiates eco-civilization construction, holds the idea of green, circular and low-carbon development, and actively promotes the revolution in energy production and consumption, and also makes an effort to save energy and reduce carbon emissions. All of those are not only China's intrinsic needs to promote coordinated domestic economic growth and environment protection as well as sustainable development, but also serve as China's strategic choices to conform to the world trend and fundamental ways to shift from a big economy in size to a big economy in power.

4.1. Carry out national low-carbon development strategies under the guidance of eco-civilization

With the rapid development of China's economy, the consumption of fossil fuels increase very fast. Despite the remarkable achievements in economic and social development, China faces an increasingly serious situation of the resources constraint, environmental pollution and ecosystem degradation. Emissions of major pollutants stay at a large quantity, far beyond the environmental carrying capacity and self-purifying capability. The air quality of most cities in China is substandard or even seriously substandard. Particularly, the more developed eastern regions including Beijing, Tianjin and Hebei are troubled by the severe haze weather more and more often, the main reason for which is coal combustion and vehicle exhaust. Coal-mined collapse area shave exceeded 1,000,000 hm^2. Events of public health and the community due to environmental pollution take place frequently, and a war against pollution has become the consensus and positive actions of governments at all levels and

the whole society. Controlling fossil energy consumption and promoting economic low-carbon transition have co-effects of saving resources and protecting environment while mitigating CO_2 emissions. Therefore, the implementation of low-carbon development strategy is also a strategic choice coordinating national and international needs to save resources, protect the environment, realize sustainable development, address global climate change, and mitigate CO_2 emissions.

The 18th National Congress of the Communist Party of China put forward to strengthen the construction of eco-civilization, with whose concept of respecting, complying with and protecting nature, green, circular and low-carbon development will be promoted, so as to reverse the trend of ecological environment deterioration from the source, satisfy the masses' expectations of a good ecological environment, and form a new model of modernization of harmonious man-nature development. That is of significant meaning for China to build a beautiful China and realize the sustainable development of the Chinese nation, and will also make an important contribution to addressing climate change and protecting global ecological security.

China incorporates eco-civilization construction into the overall strategic plan for development, which now consists of promoting economic, political, cultural, social, and ecological progress. In addition, the construction of eco-civilization is placed in a prominent position, and integrated into all aspects and the whole process of economic, political, cultural and social construction. China coordinates and promotes new industrialization, urbanization, informatization, agricultural modernization, and greenization, and treats greenization as an important goal and task of the construction of socialist modernization. Greenization will feature in the promotion of eco-civilization.

The essence of greenization is the harmonious development of human and nature, which means building and protecting a good ecological environment while sustaining economic and social development. The international concept of greenization includes not only the protection of local ecological environment, but also the response to global ecological crisis represented by climate change. Greenization not only pays attention to emission reduction of traditional pollutants and the improvement of environment quality, but also to emission reduction of CO_2 and other GHGs and the control of global warming. Therefore, in a broad sense, greenization also contains decarbonization. In particular, the United Nations established a Green Climate Fund to support developing countries in climate change adaptation and mitigation. To achieve the goals of greenization, it is necessary to firmly establish the philosophy that “Lucid waters and lush mountains are invaluable assets”. Good ecological environment is the most inclusive public product and the fairest social welfare. China should adhere to the basic policies of conservation priority, protection priority and natural recovery, and the basic approach of green, circular and low-carbon development, in order to create the spatial and industrial structures for resources saving and environment protection, a green, low-carbon way of production and life, and a good living environment for people, and make a contribution to addressing the challenges of global climate change and other ecological crisis.

As an important part of the construction of eco-civilization, China implements national strategy to deal with climate change, taking green and low-carbon development as the key area and focus of eco-civilization construction. First, during the 11th Five-Year Plan (FYP) and the 12th FYP periods, China formulated respectively the binding targets to decrease energy and CO_2 intensity of GDP, incorporated these targets into national and local plans for economic and social development, and strengthened the system of targeted responsibility of governments at all levels for energy saving and carbon reduction. Second, 42 pilot cities of low-carbon construction were developed to explore the construction model of new low-carbon cities from the areas of urban planning, industrial layout, building and transportation. In the 12th FYP period, pilot cities do better in low-carbon transition in terms of ambition and achievements than other similar areas. Third, while strengthening the fiscal and financial policy incentives, China developed pilot carbon emissions trading markets in five cities and two provinces including Beijing, Tianjin, Shanghai, Chongqing, Shenzhen, Guangdong and Hubei during the 12th FYP period, promoting energy-saving of enterprises and encouraging investment in new-energy industry through the signal of carbon price. On that basis, the national carbon market will start in 2017. Besides, China actively formulates strategies and plans for medium- and long-term low-carbon development. While carrying out the controlling objectives of energy consumption and CO_2 intensity of GDP, it explores further the implementation of the controlling objectives of the total amount of energy consumption, especially coal consumption and CO_2, thus setting up a dual-control mechanism of intensity and total. Under the guidance of the dual mechanism, China aims to establish the frame and system of low-carbon development and accelerate the economic low-carbon transformation.

China's economic development has reached a new normal of transition and upgrading, and quality and efficiency promotion. While maintaining moderately rapid GDP growth, more attention is paid to the quality and efficiency of economic development, and the coordination and sustainability of economic development and resources and the environment. Therefore, the whole Party and the entire nation should regard the construction of eco-civilization as an important political task, and, under its guidance, green and low-carbon development should be taken as the basic way to attain economic transformation and upgrading under the new normal, as well as a new advantage of comprehensive national power and international competitiveness.

4.2. Formulate and achieve ambitious INDC objectives

Before the Paris climate conference, China put forward ambitious post-2020 INDC targets, including that the CO_2 intensity of GDP decrease by 60%–65% in 2030 compared with the level of 2005, that the proportion of non-fossil energy

in primary energy consumption increase to about 20%, and that CO_2 emissions peak around 2030 or earlier. Guided by those goals, China will accelerate the revolution in energy production and consumption, and promote the transformation of economic growth pattern (NDRC, 2015).

China is now in the stage of rapid industrialization and urbanization, therefore, it is necessary to coordinate economic growth and CO_2 emission reduction. First of all, the output efficiency of per unit energy consumption or per unit carbon emissions needs to be improved. Thus, the goal to reduce the CO_2 intensity of GDP becomes the core indicator and the key focus in coordinating domestic sustainable development and response to global climate change. If the decrease rate of annual CO_2 intensity of GDP became more than the increase rate of annual GDP growth, CO_2 emissions would peak and the total amount would begin to decline. To realize a substantial drop in CO_2 intensity of GDP, there are two ways. One is to vigorously save energy, improve energy efficiency, continuously reduce the energy intensity of GDP, and control the growth of total energy consumption. The other is to vigorously develop new and renewable energy, improve energy structure, and reduce CO_2 intensity of energy consumption. Through the above ways, the increment of total energy demand could be satisfied with non-fossil energy supply increase, fossil energy consumption would no longer grow, and CO_2 emissions would also peak.

To lower the CO_2 intensity of GDP in 2030 by 60%−65% than that of 2005, the annual decline rate of the intensity need to be more than 4%, which means more efforts should be made than to achieve the 40%−45% decrease of CO_2 intensity of GDP in 2020. From 2005 to 2015, China's CO_2 intensity of GDP declined by 38.3% (NBSC, 2015), while that of developed countries only decreased by about 15% in the same period (IEA, 2015). Calculating the decrease of CO_2 intensity of GDP of the European Union, the United States and other developed countries based on their proposed absolute GHG emission reduction targets in their INDCs, considering their future GDP growths, the intensity decrease rates are less than 4%. That also shows China's high ambition in its INDC targets from another perspective.

China intends to achieve the peak of CO_2 emissions by 2030, which is earlier than developed countries in terms of development stage. The potential GDP growth rate at that time would still be relatively high, at about 4%−5%. To achieve CO_2 emissions peak, the annual decline rate of CO_2 intensity of GDP also needs to reach 4%−5% on the occasion. Developed countries' GDP growth rates are relatively low at the peaks of CO_2 emissions, generally not higher than 3%, therefore, the total decline of CO_2 emissions can be achieved when their annual decrease rates of CO_2 intensity of GDP approach 3%. China needs faster decrease than developed countries in CO_2 intensity of GDP when the CO_2 emissions peak (He, 2013). Besides energy saving and energy efficiency promotion, it is important to raise the proportion of non-fossil energy to about 20% in 2030, when annual supply of non-fossil energy would reach about 1.2 Gtce, equaling the sum of energy consumption in Japan, the United Kingdom and Germany. Moreover, when the time comes, the new and renewable energy industry system would be good, the relevant techniques be advanced, economical and feasible, and the scale of the industry would continuously increase with an annual growth rate of 6%−8%, therefore, non-fossil energy supply increase could meet the newly-added energy demand with economic development, and CO_2 emissions could peak as the fossil energy consumption would no longer grow. China's new and renewable energy development in the future will far exceed that of other countries in terms of speed and scale (He, 2013).

Peaking of CO_2 emissions will become an important turning point in the transformation of China's economic development. Peaking of CO_2 emissions means economic and social development completely decouples from fossil energy consumption growth, sustainable economic development is no longer dependent on fossil fuel growth and occupies no more capacity of the earth's environment. That will be an important milestone in China's response to climate change, a symbol of the fundamental improvement of domestic resource and environment situation, and be of significance for the construction of eco-civilization.

4.3. Positively adapt to the urgent situation under the global long-term goals for addressing climate change

The Paris Agreement establishes a long-term goal that is to control global temperature rise below 2 °C or even 1.5 °C with arduous efforts. To achieve the goal, global GHG emissions must reach the peak as soon as possible and begin to decline, decreasing to 40 Gt CO_2-eq in 2030 from 50 Gt CO_2-eq in 2010. Based on the parties' current INDC targets, emissions are calculated to be 55 Gt CO_2-eq in 2030, so there is an annual gap of 15 Gt CO_2-eq in emissions reduction (UNFCCC, 2015; IPCC, 2014). The Agreement decides to take stock of the collective efforts of Parties on a regular basis in order to provide information for Parties, enhance their ambition in emission reduction in their updated INDC objectives, and bridge the gap mentioned above. Therefore, all countries should continuously strengthen their actions. Net zero-emission of GHGs should be achieved in the second half of the 21st century, thus global emission reduction will be extremely urgent, and all countries are facing serious challenges and arduous tasks.

As a big part of developing countries and carbon emissions, China draws pretty much attention to its emission reduction targets and achievements. The urgent global target in temperature rise control makes it impossible for developing countries to take the pathway of modernization supported by high energy consumption and high carbon emissions created by developed countries. Under the bottom-up voluntary emission reduction mechanism of the Paris Agreement, the international community will not impose emission reduction obligations beyond national conditions, development stages and capacity. However, because of the urgent situation of global climate change, China has to conform to the trend, accelerating economic low-carbon transformation and forming

a favorable system, mechanism and development pattern to promote low-carbon development, and should by no means stick to the traditional high-carbon development path. Otherwise, the continuously shrunk global carbon emission space will become the rigid constraint of sustainable economic and social development. Not only will China receive increasing pressure in the international community, but also lose the opportunity to take a climate-friendly and low-carbon development path, and may also lose the national capacity for sustainable development and the economic and technical international competitiveness, thereby falling into a passive position. On the other hand, in the current process of worldwide voluntary cooperation in addressing the threat of climate change, building the community of common destiny for all mankind, and protecting mankind's common interests, only through positive acts and contribution, can a country have discourse power and influence in global governance, and play a leading role in global governance.

In order to achieve global long-term goal, the Paris Climate Conference decided all parties should formulate and submit their strategies for low GHG emissions in the middle of the 21st century by 2020. China has to conform to the global trend of low-carbon transformation and carry out a forward-looking deployment. First, China should accelerate energy production and consumption revolution, establish clean, low-carbon, safe and efficient energy supply and consumption systems, and study and work out the long-term low-carbon development goals and paths. By 2050, China's total energy demand should fall to the current level, the proportion of non-fossil energy in primary energy consumption should try to reach 50%, and the CO_2 emissions should try to decrease above 50% of the peak level. Only in that way is it likely for China to form a sustainable energy system with new and renewable energy as the main body and realize an approximate zero CO_2 emissions in the second half of the 21st century (He, 2013, 2015a).

In order to adapt to the urgent process of worldwide decarbonization, China should take the global long-term emission reduction objective as the guide and formulate its own long-term objectives and strategies for energy revolution. The energy production and consumption systems of approximate zero CO_2 emissions with new and renewable energy as the main body should be basically established in the second half of the 21st century, which needs a forward-looking deployment. At present, China need to follow the trend of global energy revolution, strengthening the research, development and industrialization of advanced energy technology. In addition to the development of wind power, solar energy, hydropower, biomass and other renewable energy technologies and industries, the research and development of smart grid and energy storage technology should be strengthened so as to meet the safety, stability and absorbing capacity of the high-proportion renewable energy power connected into the grid. Meanwhile, nuclear power should be developed safely and efficiently, because it is stable in operation and competitive in cost, and plays an irreplaceable role in energy system low-carbon transformation. Nuclear technology is a cutting-edge high-tech industry mastered only by a few countries in the world, and it has a vast market throughout the world and particularly in developing countries. Therefore, it should become an important area for China to improve its core competitiveness of advanced energy technology worldwide in the future. Besides, China should attach importance to the research, development and demonstration of CO_2 capture and storage (CCS) technology. Despite of the relatively high cost at the early period and lack of co-effects with other aspects, CCS would be an important technological option under the urgency of emission reduction, the relatively high carbon price and high social marginal cost of CO_2 emission reduction. Thus, it has the space and potential for development. In a word, the strategy, path and technology roadmap of China's long-term low-carbon transformation need to be studied and planned according to the long-term global low carbon targets and trends.

China is facing more difficult tasks than developed countries in achieving low-carbon transformation. As for developed countries in the stage of post-industrialization, economic development shows intensive growth mainly, and energy demand has basically saturated; therefore, the absolute decline of CO_2 emissions can be realized through promoting energy reform and developing new and renewable energy in replace of the original fossil energy consumption stock. However, China is in rapid industrialization and urbanization, and the energy demand would continue to increase in quite a long period of time with the relatively fast economic growth. New and renewable energy developed by China should first satisfy the "increment" of total energy demand, then slow the growth of fossil energy, and then can it further substitute the stock of the original fossil energy consumption. Due to the continuously growing energy demand, energy system reform of China becomes more difficult. The United States Clean Power Plan proposed to cut CO_2 emissions from power system by 32% in 2030 compared with the level of 2005, which could be achieved through increasing renewable energy power by 0.1–0.2 billion kW, adding natural gas power by 0.05–0.1 billion kW, and decreasing coal power by 0.15 billion kW from now on based on the basically stable electricity demand. As for China, however, to achieve the goal of a 20% proportion of non-fossil energy in 2030, from now on, it needs to add new non-fossil energy capacity by about 1 billion kW, above 5 times more than the U.S. in the newly-added capacity of the same period. Nevertheless, China's CO_2 emissions from power system would still increase by 30% above the level of 2010 as its power demand in 2030 could be twice more than that in 2010. China lags behind developed countries in the development stage, and will face more severe challenges and more arduous tasks in economic and energy low-carbon transformation. Therefore, China needs to make greater efforts, converting those challenges and tasks into opportunities for development (He, 2013, 2015a).

5. Stride over the Middle Income Trap within novation-driven and low-carbon development

At present, China's economic development reaches a new normal characterized by increase rate shift, structure

adjustment and motive power transition. GDP growth speed changes from a high rate of about 10% into a relatively high rate of about 7%. Moreover, industrial quality and efficiency promotion accelerates the adjustment of economic structure, and the driving force of economic development converts from factor- and investment-driven into innovation-driven. Under the new normal, China will pay more attention to the quality and efficiency of economic development.

Under the new normal, with the conversion of development pattern and motive power, infrastructure construction and capacity expansion will slow, and the demand of iron, steel, cement and other high energy consuming products and raw materials will decrease, which contribute to the optimization and upgrading of industrial structure and help to control the growth of energy consumption, thereby accelerating the economic low-carbon transition. Energy consumption elasticity was 0.59 in the 11th FYP period, and falls to 0.46 in the 12th FYP period, and may further drop to about 0.30 in the13th FYP period. Besides, in the13th FYP period, coal consumption would reach the peak, the total energy demand growth would mainly be satisfied by the increase of non-fossil energy supply, and the increase of CO_2 emissions would be effectively controlled, all of which could lay the foundation for the peaking of CO_2 emissions (He, 2013).

Current low-carbon transformation under the new normal also faces many challenges. Economic growth downward pressure continues to increase, and the potential for economic development tends to weaken. In addition, there is a lack of new high-tech industrial growth sources due to insufficient scientific and technological innovation ability. Transformation and upgrading of traditional industries also encounter difficulties in that the extensive mode of development cannot sustain, but the intensive development is short of innovation support. In the current circumstances, local governments and enterprises are likely to seek a way out for traditional industries, continuing to expand the original development model. The coal industry and coal-fired power plants in serious over-capacity may also seek new uses which reduces the space of future new and renewable energy development. However, the central government vigorously will promote the supply-side structural reform, advance industrial quality and efficiency promotion, and shut down the backward and over capacity of high energy consuming industries, which all further the economic low-carbon transition. Around 2020, the terminal energy consumption and CO_2 emissions from the industrial sector should reach the peak and enter a new stage of intensive development and contribute to the peaking of CO_2 emissions around 2030.

Faced with so many difficulties in economic transformation under the new normal, whether China's economic development will fall into the so-called Middle Income Trap has become a widespread concern at home and abroad (He, 2015b). According to per capita gross national income (GNI), the World Bank divides all countries into four categories, namely, high-income, upper-middle-income, lower-middle-income and low-income countries. The level is adjusted with development and price index changes. Particularly, the per capita GNI level for lower-middle, upper-middle and high incomes were $1045, $4125 and $12736 respectively in 2014 (WB, 2014). The concept of Middle Income Trap, put forward by the World Bank in 2007, refers to a situation that, after a country attains the middle-income level, it cannot reach the high-income level for a long time because of slow or even stagnant economic growth, which brings about a series of economic and social problems, with Brazil, Argentina and other Latin American countries and Malaysia, Indonesia and other Southeast Asian countries as the representatives. In the 1960's, among 101 middle-income countries or regions, only 13 countries or regions become high-income countries by 2008 (He, 2015b; WB, 2014; WB and DRCSC, 2015). Thus, Middle Income Trap describes a prevailing phenomenon. Though the reason is quite complex and conditions in different countries are not the same, there is a consensus that, development from low income to middle income mainly depends on the input of production factors including labor, capital, etc. and the low-cost expansion of simple techniques, however, with the loss of low cost advantage and industrial structure adjustment and upgrading, development from middle income to high income relies on the innovation drive and the promotion of production rate of comprehensive production factors. Therefore, development strategies and models for low income to middle income no longer meets the need of the development from middle income to high income. The reason why a country falls into the Middle Income Trap is that fundamental adjustment and transformation are not realized in its economic and social system and economic development pattern, and development stagnates in lack of new motive power (He, 2015b; WB, 2014; WB and DRCSC, 2015; Cai, 2011).

Since the reform and opening up, China has experienced rapid economic growth. In 1997, the GNI per capita reached $785, exceeding the lower-middle income level of $755 formulated by the World Bank. Since then, China has become a middle-income country from a low-income one. In 2010, China's GNI per capita attained $4400, more than the upper-middle income level of $3976. In 2014, the GNI per capita reached $7476, accounting for 58.7% of the value of the high-income level (He, 2015b; WB, 2014). According to the current development trend, China is expected to join in the high-income countries before 2025.

Many countries have encountered problems in the transition stage from middle-income level to high-income level. Now similar problems appear in China, such as insufficient driving force for economic development, lack of new economic growth sources, rising labor costs, and unfair distribution of social wealth, etc. Therefore, China is also facing challenges and risks of falling into the Middle Income Trap. Like the majority of middle-income countries, the resource dependent, investment driven and extensive development pattern adopted for reaching the middle-income level cannot sustain. China has to convert the development strategy and pattern, and take a new innovation-driven, intensive, resource saving, and environment friendly pathway, so as to promote the coordinated and sustainable development between the society, economy, the environment and resources. In the setting of global

response to climate change and low-carbon transformation, China should conform to the world trend, promoting economic and social low-carbon transformation and enhancing the national competitiveness of low-carbon development. Under the new normal, the in-depth economic adjustment, development driving force conversion, development pattern transition, and economic structure optimization will effectively change the resource-dependent and extensive high carbon development pattern and have China walk on an innovation-driven, intensive, green, and low-carbon development path. Therefore, adhering to innovation-driven and low-carbon development will become a way for China to successfully stride over Middle Income Trap, creating a multi-win-win situation of growing economy, promoted environment and reduced CO_2 emissions. That also serve as the strategy for China to change from a big economy in size to a big economy in power, and enhance the international competitiveness, so as to play a leading role in global environmental governance and reflect its consciousness of responsibility as a big nation.

References

Cai, F., 2011. Theory, experience and pertinence of middle income trap. Econ. Perspect. 12, 4−9.

He, J.-K., 2013. Analysis of peaking of CO_2: China's emission reduction targets and countermeasures. Chin. J. Popul. Resour. Environ. 23 (12), 1−9 (in Chinese).

He, J.-K., 2014. New energy system revolution is the only way to the eco-civilization. J. China Univ. Geosci. Soc. Sci. Ed. 14 (2), 1−10 (in Chinese).

He, J.-K., 2015a. Strategies for China's energy reform and low-carbon development. Wuhan Univ. J. Philos. Soc. Sci. 68 (1), 1−18 (in Chinese).

He, X.-Y., 2015b. China's Long-term Low-carbon Development Pathway under the Guidance of Eco-civilization. Doctoral Dissertation of Tsinghua University, Beijing (in Chinese).

He, J.-K., Teng, F., Qi, Y., 2014. Research tasks and direction of new climate economics. Chin. J. Popul. Resour. Environ. 24 (8), 1−8 (in Chinese).

IEA (International Energy Agency), 2015. CO_2 emission from Fuel Combustion 2015. International Energy Agency, Paris.

IPCC, 2014. Climate Change 2014: Summary for Policymakers. Cambridge University Press, Cambridge.

Jeremy, R., 2009. The Third Industrial Revolution. China CITIC Press, Beijing (in Chinese) (Zhang, T.-W., Sun, Y.-N., Trans).

NBSC (National Bureau of Statistics of China), 2015. China Statistical Yearbook 2015. China Statistics Press, Beijing (in Chinese).

NDRC (National Development and Reform Commission), 2015. To Strengthen Actions Dealing with Climate Change: INDC. http://www.gov.cn/ (in Chinese).

UN (United Nations), 2012. The Future We Want. Rio + 20 United Nations Conference on Sustainable Development. http://www.un.org/en/sustainablefuture/ (in Chinese).

UNFCCC (United Nations Framework Convention on Climate Change), 2015. The Paris Agreement. http://unfccc.int/resource/docs/2015/cop21/chi/l09r01c.pdf. Paris.

WB (World Bank), 2014. World Development Report 2014. Tsinghua University Press, Beijing (in Chinese).

WB (World Bank), DRCSC (Development Research Center of the State Council), 2015. China in 2030: to Build a Modern, Harmonious and Creative High-income Society (in Chinese).